A Quality Improvement Initiative to Reduce Gastrostomy Tube Placement in Aspirating Patients

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abstract

OBJECTIVES: Oropharyngeal dysphagia and aspiration may occur in infants and children. Currently, there is wide practice variation regarding when to feed children orally or place more permanent gastrostomy tube placement. Through implementation of an evidence-based guideline (EBG), we aimed to standardize the approach to these patients and reduce the rates of gastrostomy tube placement.

METHODS: Between January 2014 and December 2018, we designed and implemented a quality improvement intervention creating an EBG to be used by gastroenterologists evaluating patients ≤2 years of age with respiratory symptoms who were found to aspirate on videofluoroscopic swallow study (VFSS). Our primary aim was to encourage oral feeding and decrease the use of gastrostomy tube placement by 10% within 1 year of EBG initiation; balancing measures included total hospital readmissions or emergency department (ED) visits within 6 months of the abnormal VFSS.

RESULTS: A total of 1668 patients (27.2%) were found to have aspiration or penetration noted on an initial VFSS during our initiative. Mean gastrostomy tube placement in these patients was 10.9% at the start of our EBG implementation and fell to 5.2% approximately 1 year after EBG initiation; this improvement was sustained throughout the next 3 years. Our balancing measures of ED visits and hospital readmissions also did not change during this time period.

CONCLUSIONS: Through implementation of this EBG, we reduced gastrostomy tube placement by 50% in patients presenting with oropharyngeal dysphagia and aspiration, without increasing subsequent hospital admissions or ED visits.

Oropharyngeal dysphagia with aspiration in infants and children is commonly found in patients with complex medical disease as well as healthy infants and children.[1–5] The incidence of aspiration, as documented by videofluoroscopic swallow study (VFSS), which is thought to be the gold standard for diagnosis, occurs in ∼28% to 68% pediatric patients, depending on their comorbidities.[2,6–8] Often, swallow function improves over time, so treatment is often supportive and includes adjustments to patients' oral feeding regimen, including thickening of feeds. Occasionally, some infants and children may require placement of an enteral feeding tube (gastrostomy tube).[9–12]

There are limited data on which patients can be fed orally and which need enteral tube placement. Many

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Dr McSweeney conceptualized and designed the quality improvement initiative and data review and analysis and drafted the manuscript; Ms Meleedy-Rey assisted in the quality improvement initiative and data collection and analysis; Ms Kerr and Ms Chan Yuen assisted in the quality improvement initiative and data review; Mr Fournier assisted in the data collection and review; Ms Norris assisted in the cost analyses; Ms Larson assisted in the study design and data review; Dr Rosen conceptualized and designed the quality improvement initiative, participated in the analysis, and drafted the manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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studies offer only a cross-sectional glimpse into the decision-making although swallow function often changes over time.[7] The decision and timing of gastrostomy tube placement often varies from provider to provider on the basis of their level of comfort in recommending thickened feeds and their experience managing patients with respiratory symptoms. Previous data have shown that when infants and children with aspiration were treated with gastrostomy tube placement, these patients had twice as many hospitalizations as compared with those patients fed orally with thickened feedings.[12] In addition, continued oral feeding may be beneficial to improving neurologic outcomes and weight gain, even in medically complex patients. Therefore, the decision to place a gastrostomy tube needs to be carefully considered.[11,13–15]

With increasing rates of gastrostomy placement nationally, especially in infants, clinical guidelines are needed to encourage safe oral feeding when possible.[16–18] Although intended to improve quality of life, placement of gastrostomy tubes sometimes has unforeseen consequences, including postsurgical complications and increase postsurgical costs.[7,16,19–21] Therefore, we implemented an evidence-based guideline (EBG) to standardize and reduce the rates of gastrostomy tube placement in infants and young children with aspiration. Our primary aim was to decrease the placements of gastrostomy tubes by 10% over a 1-year period of time.

METHODS

Study Design and Setting

We performed a quality improvement intervention to standardize the care of aspirating patients at risk for placement of a gastrostomy tube. This project received approval as a quality improvement initiative from our hospital's performance excellence group, a hospital-based committee that oversees all quality improvement initiatives at the hospital. The setting of this initiative took place within the division of gastroenterology at Boston Children's Hospital (BCH), a tertiary-care academic children's hospital with a main campus and 11 satellite clinics in the Boston metropolitan area. Providers included 55 gastroenterologists, 16 nurse practitioners, 15 nurses, and 13 gastroenterology fellows. At our institution, gastroenterologists are consulted perioperatively to assess the need for gastrostomy tube placement.

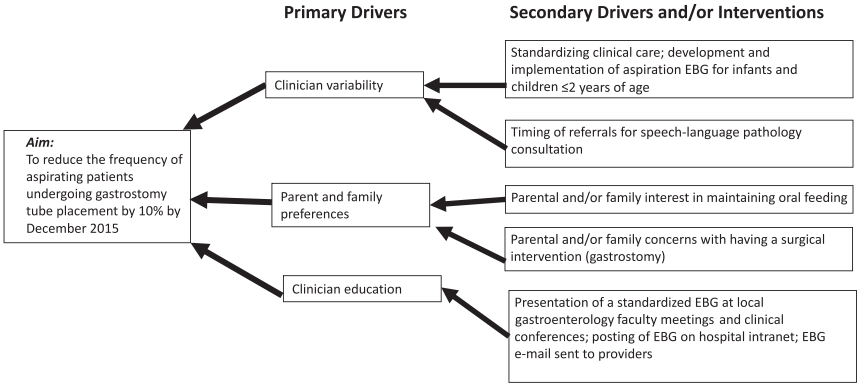

FIGURE 1
Key driver diagram for decreasing the use of gastrostomy tube placement in infants and children ≤2 years of age with aspiration.

Intervention

Designed by gastroenterologists in the aerodigestive center and the department of pediatrics quality improvement team, an EBG was developed to standardize the initial evaluation and management of aspirating infants and children ≤2 years of age presenting to outpatient gastroenterology clinics at BCH. Our primary aim with this project was to encourage safe oral feeding while decreasing the use of gastrostomy tube placement by 10% within 1 year of the EBG launch date on January 1, 2015. We set a goal of 10% because we felt that the decision to proceed to gastrostomy was complex, and aspiration risk was only 1 part of the decision-making process, thus making more aggressive reductions less feasible. We generated a key driver diagram to identify the primary drivers of provider variability in their clinical practice leading to gastrostomy tube placement in infants and children with oropharyngeal dysphagia at our institution; we chose to target clinician variability and education as part of this initiative (Fig 1).

The guideline was developed through a review of the literature, along with input from the department of pediatrics quality improvement, as well as motility, aerodigestive, general gastroenterology; and speech-language pathology teams. Between September 2013 and December 2014, a draft guideline was presented for feedback at multiple intradivisional educational and faculty meetings and revised where appropriate. In addition, members of the aerodigestive center gave informational talks to the divisions of gastroenterology, pulmonology, and hospitalist medicine teams about aspiration management.

The EBG was then launched and made available in January 2015 by e-mail, on the hospital intranet, and eventually by a "quick link" on the

hospital home page to clinical providers. Between January 2015 and December 2018, annual reviews of the guideline for content updates were performed, and quarterly reviews of outcome data were conducted at various staff meetings, division of gastroenterology grand rounds, and quality improvement meetings. For any gastroenterology providers uncomfortable following the EBG, they were able to refer patients to our aerodigestive center for management. During the course of this guideline, some of the recommendations for commercially available thickening agents changed over time; therefore, continued modification of this EBG algorithm was needed annually to reflect these changes.

The guideline's inclusion criteria included infants and children ≤2 years of age with symptoms consistent with aspiration, defined as having a VFSS revealing evidence of aspiration or penetration of at least 1 consistency. There were no patients who were excluded from the algorithm. The key tenets of the guideline were obtaining a VFSS in any patient with suspected aspiration and having a trial of thickened or nasogastric tube feedings, when possible, before moving forward with gastrostomy tube placement.[7,22] The final guideline consisted of a 2-page flowchart incorporating different feeding pathways (Fig 2). Patients' and families' preferences for continuing with nasogastric feeding versus moving ahead with more permanent enteral tube placement were also taken into consideration. Nasogastric tubes were allowed to remain for up to 1 year if desired and no adverse consequences ensued.

Study Patients and Data Collection

Medical records between January 2014 and January 2015 were reviewed for all infants and children ≤2 years age who had an initial VFSS that had positive results for aspiration or penetration; these data served as our baseline rate of aspiration and subsequent gastrostomy tube placement before EBG initiation. Subsequently, medical records were tracked quarterly between January 2015 and December 2018 to monitor the impact of our guideline on gastrostomy tube placement rates. We excluded any patients from the analysis who had (1) already undergone tube placement before their first VFSS, (2) any patients >2 years age at the time of their first VFSS, and (3) any patient ≤2 years of age whose VFSS was not their initial study.

Records were reviewed quarterly, and a positive score for the presence of "aspiration" or "penetration" (designated abnormal VFSS) was assigned on the basis of the speech-language pathologist's electronic medical record report from the VFSS. Laryngeal penetration was included because of its potential clinical significance for aspiration.[10] Seven evaluators reviewed the VFSS reports; any discrepancies between reviewers resulted in continued review to achieve consensus by using a standardized manual of operations. Scoring agreement was conducted to confirm consistency with identification of patients with aspiration or penetration (k- 1.0 for aspiration and 0.7368 for penetration).

Demographics of patients with positive VFSS results were also reviewed along with a baseline medical complexity score, which was calculated on the basis of previously published pediatric medical complexity algorithms.[23,24] All charts with a positive VFSS result were followed prospectively to determine if patients underwent a gastrostomy tube placement within 6 months of initial VFSS. The following *Current Procedural Terminology* procedures were used to identify tube placement: 49440, 49441, 43246, 44372, 43653, 43830–43832. Any patient who maintained on nasogastric feeding and/or oral feeding and did not go on to gastrostomy tube placement during the first 6 months was considered a non-gastrostomy–treated patient.

Measures

The primary outcome measure was the frequency of patients with an abnormal VFSS who went on to have gastrostomy tube placement within 6 months of their first abnormal VFSS. We also monitored the frequency of VFSS usage per quarter (total VFSSs performed, frequency of first VFSS performed at BCH, and frequency of abnormal studies) over time. We used these data as a proxy of providers' adherence to our algorithm's suggestion for assessing swallowing function objectively with a VFSS before any tube placement. The total frequency of repeat VFSSs within 12 months was observed in patients found to have aspiration versus isolated laryngeal penetration on their initial abnormal VFSS because recent data also now support a trial of slow weaning of thickening agents in certain patients before a repeat VFSS.[25]

To ensure that oral feeding did not result in an increase in the number of admissions or emergency department (ED) visits, we tracked both as balancing measures. We assessed the frequency of total hospital admissions and ED visits within 6 months of patients' initial abnormal swallow study; we also reviewed the primary diagnoses noted for their hospital admission or ED visits to review trends for ED visits or readmissions. Similarly, to assure that there were no increased hidden costs to the EBG, we performed cost comparisons within a year of the initial VFSS on a cohort of patients (2014–2017) for whom we had complete financial data and compared estimated total hospital costs per patient in those treated with a gastrostomy tube with those who were not.

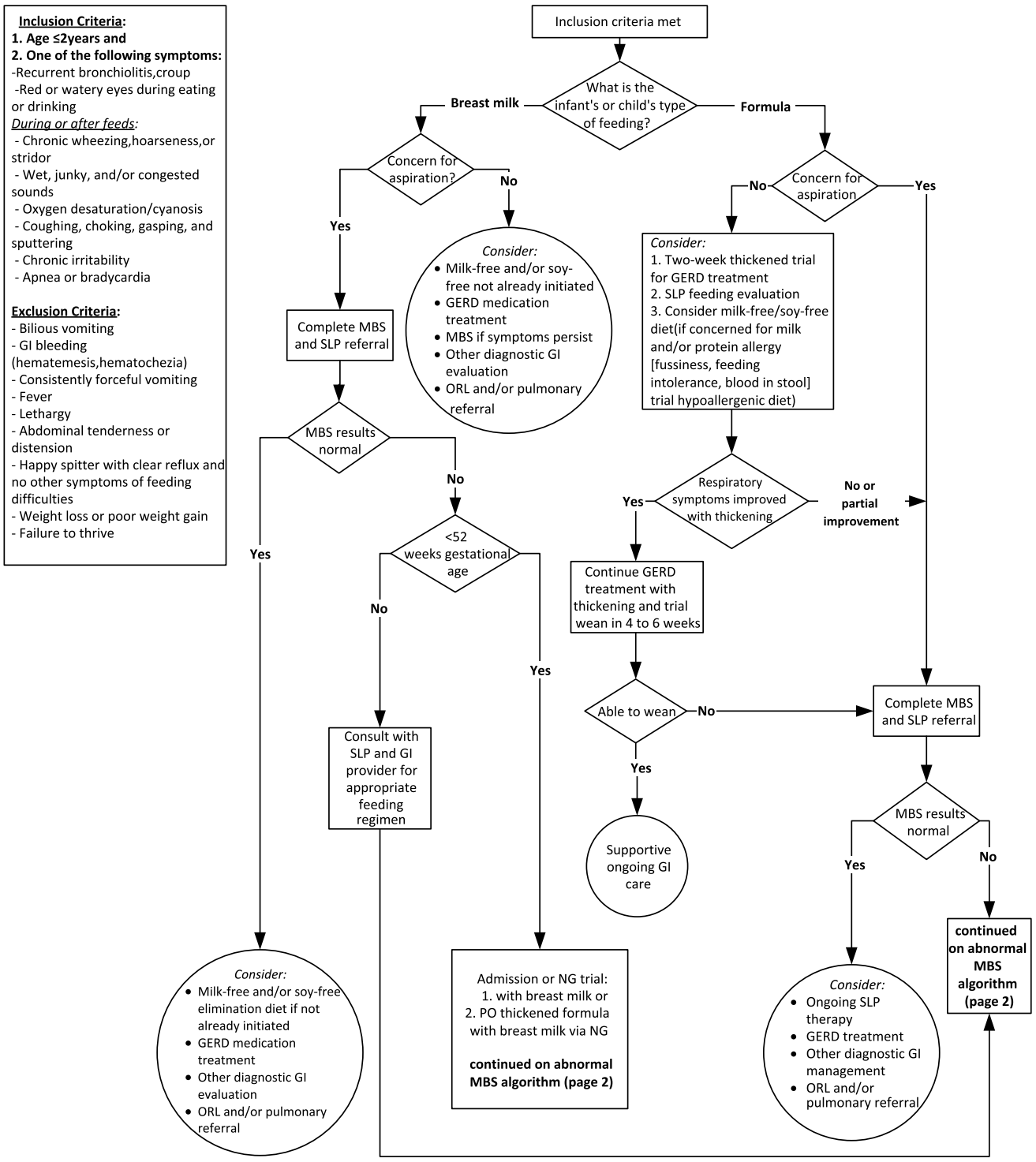

FIGURE 2

Aspiration EBG for feeding evaluation before gastrostomy tube placement. This pathway was developed for educational purposes only. The pathway is based on medical evidence and/or professional opinion of clinicians at BCH. Decisions about evaluation and treatment are the responsibility of the treating clinician and should always be tailored to individual clinical circumstances. GERD, gastroesophageal reflux disease; GI, gastroenterology; G-tube, gastrostomy tube; MBS, fluoroscopic modified barium swallow study; NG, nasogastric tube; ORL, otolaryngology; PO, oral; SLP, speech-language pathologist; UGI, fluoroscopic upper gastrointestinal series.

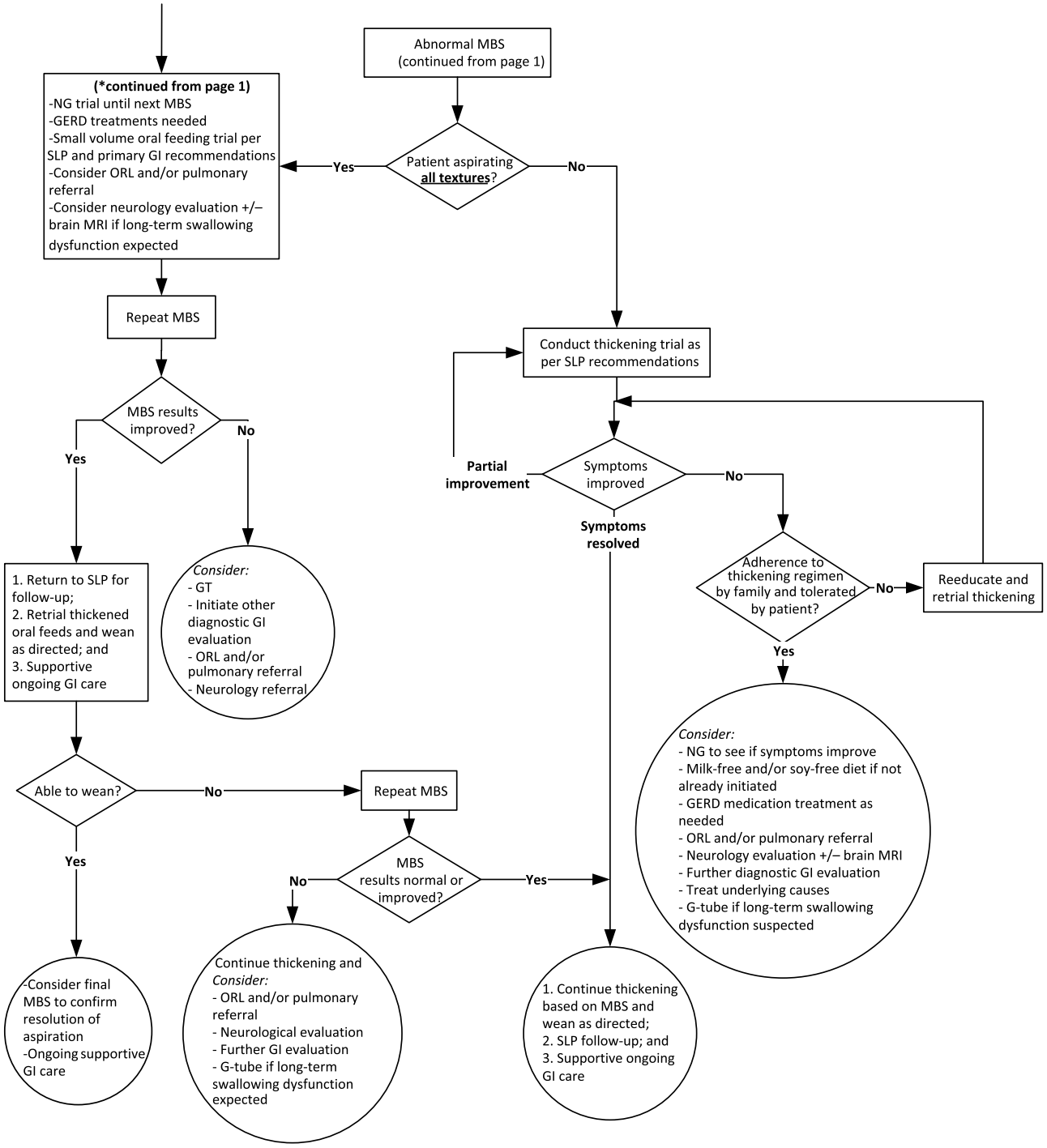

FIGURE 2
Continued.

Data Analysis and Statistical Analyses

Frequency of gastrostomy tube placement rates within 6 months of initial abnormal VFSS was tracked by using a p-chart with control limits set as 3 SDs.[26,27] Standard statistical quality control chart criteria were used for determining if observed changes were due to common-cause variation or special-cause variation.[27] Comparisons of tube placement rates were made between patients found to have aspiration or penetration before the guideline was implemented (January 1, 2014–December 31, 2014) versus after implementation (January 1, 2015–December 31, 2018). Demographic data on patients undergoing VFSS were also performed by using frequencies and descriptive statistics. Frequencies of ED visits and hospital admissions for patients receiving gastrostomy tube placement versus those who did not were observed quarterly by using line graphs to examine trends in these balancing measures.[27] We used SQCpack version 7.0 (PQ Systems, Dayton, OH) for creating the statistical process charts. All other analyses were performed by using SAS 9.4 (SAS Institute, Inc, Cary, NC).

TABLE 1 Demographics of Patients With Abnormal VFSSs

	No Surgery	Gastrostomy Tube Surgery	*P*
N = 1668, *n*	1543	125	—
Male sex, *n* (%)	940 (61%)	64 (51%)	.0327
Wt in kg, mean (SD)	7.7 (±2.6)	5.6 (±2.1)	.0001
Age in mo, mean (SD)	9 (±6)	6 (±6)	.0001
Complexity category[a], *n* (%)			
No category assigned	932 (60)	71 (57)	.4291
One or more categories assigned[b]	611 (40)	54 (43)	
Cardiovascular	347 (22)	44 (35)	.1991
Respiratory	277 (18)	19 (15)	.1466
Congenital and/or genetic	170 (11)	23 (18)	.1648
Gastrointestinal	94 (6)	57 (46)	<.0001
Neuromuscular	116 (7)	32 (26)	<.0001
Other[c]	269 (17)	54 (43)	.0129

[a] Calculated by using the Pediatric Medical Complexity Algorithm.
[b] Categories not mutually exclusive.
[c] Prematurity, renal, metabolic, hematologic/oncologic, or other miscellaneous comorbidities.

RESULTS

We identified 6125 patients ≤2 years of age who had completed a VFSS between January 1, 2014, and December 31, 2018. A total of 1668 patients (27.2%) were found to have aspiration or penetration noted on initial VFSS during this time; demographics for these patients with abnormal VFSS, including complexity scores, are noted in Table 1. A total of 768 patients were found to have aspiration or aspiration and penetration on their first VFSS; 900 patients were found to have penetration only on the first VFSS. Ninety-four of 768 (12.2%) with documented aspiration went on to require gastrostomy tube placement versus 31 of 900 (3.4%) patients with penetration only went on to gastrostomy tube placement. During the course of this project, mean gastrostomy tube placement fell from 10.9% at the start of EBG implementation to 5.2% almost a year after EBG initiation; this improvement was sustained throughout the next 3 years of EBG usage and monitoring (Fig 3).

Frequency of total VFSS performed increased over time after initiation of our EBG (including the number of first VFSS performed at our institution as well as frequency of reported abnormal studies; Fig 4). Patients with aspiration on their initial VFSS had a higher percentage of having a repeat VFSS within a year (451 of 768; 58%) versus patients who were found to have penetration only on their initial VFSS (178 of 900; 19.8%).

Despite the reduction in gastrostomy tube placement, rates of ED visits or hospital admissions (per patient) remained consistent over time as shown in Figs 5 and 6. Patients undergoing gastrostomy tube placement had on average 1.4 ED visits per patient or 1.8 admissions per patient over a 6-month period. By comparison, patients who did not undergo gastrostomy placement had 0.3 ED visits per patient ($P < .0001$) or 0.4 admissions per patient ($P < .0001$). The top 5 most common diagnoses given for ED visits, among all patients enrolled in the EBG, included gastrostomy malfunction (18%), unspecified acute upper respiratory infection (9.6%), unspecified fever (9%), vomiting (5.7%), and feeding difficulties (3.75%). Similarly, the 5 most common diagnoses associated with admissions for all patients enrolled in the EBG were feeding difficulties (10%), gastroesophageal reflux disease without esophagitis (6.6%), congenital laryngomalacia (5.2%), failure to thrive, child (4.8%), and dysphagia, oropharyngeal phase (3.43%). Total hospital costs per patient were also found to be 9 times higher for patients with abnormal VFSS treated with a gastrostomy tube ($140 666 per patient) versus those patients without a gastrostomy tube ($15 616 per patient).

DISCUSSION

Using this EBG, we were able to successfully reduce the use of gastrostomy tube placement by almost half. This reduction surpassed our initial 10% goal and has been sustained in the subsequent 3 years of monitoring. We feel that we were able to achieve our target through

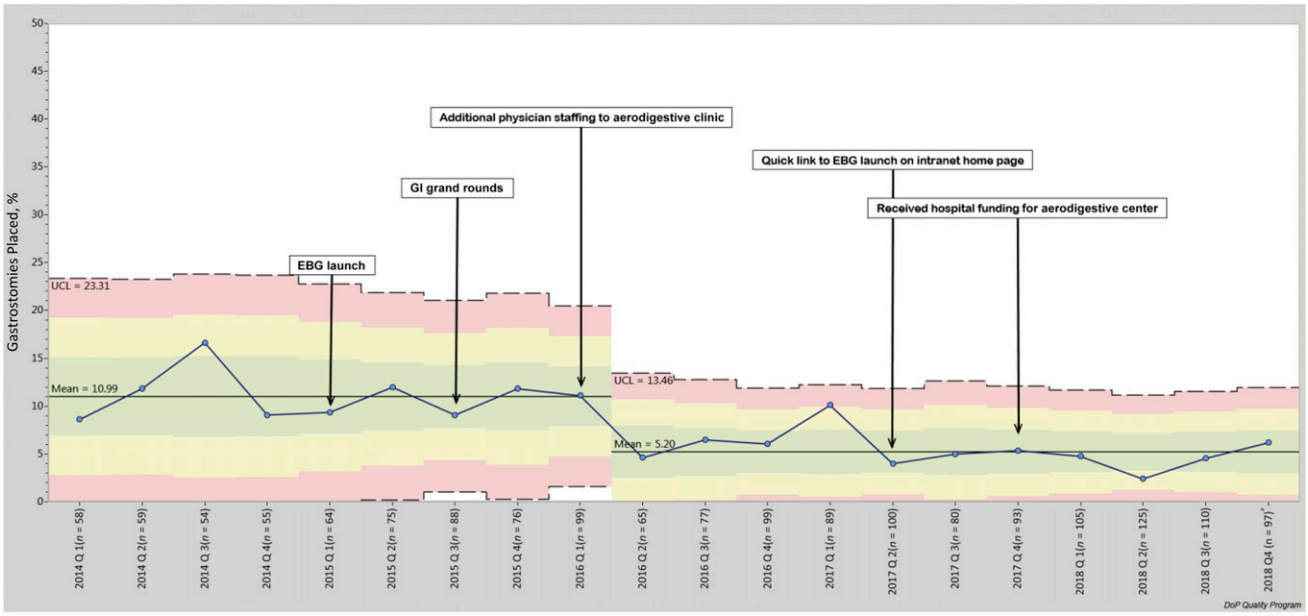

FIGURE 3

Statistical control chart revealing gastrostomy tube rates over time with control limits set to 3 SDs. The percentage of gastrostomy placed within 6 months of positive VFSS results are shown. [a] Through June 1, 2019. DoP, department of pediatrics; GI, gastroenterology; Q, quarter; UCL, upper control limit.

offering continued education and support for our colleagues on guideline use and promoting oral feedings in patients when possible. With the increasing trend both locally and nationally to place gastrostomy tubes in younger infants, we felt this guideline may provide a scaffold to reduce gastrostomies nationally.[16]

To ensure that oral feeding did not result in increased respiratory morbidity, the balancing measures of ED visits and hospitalizations were especially important to track,

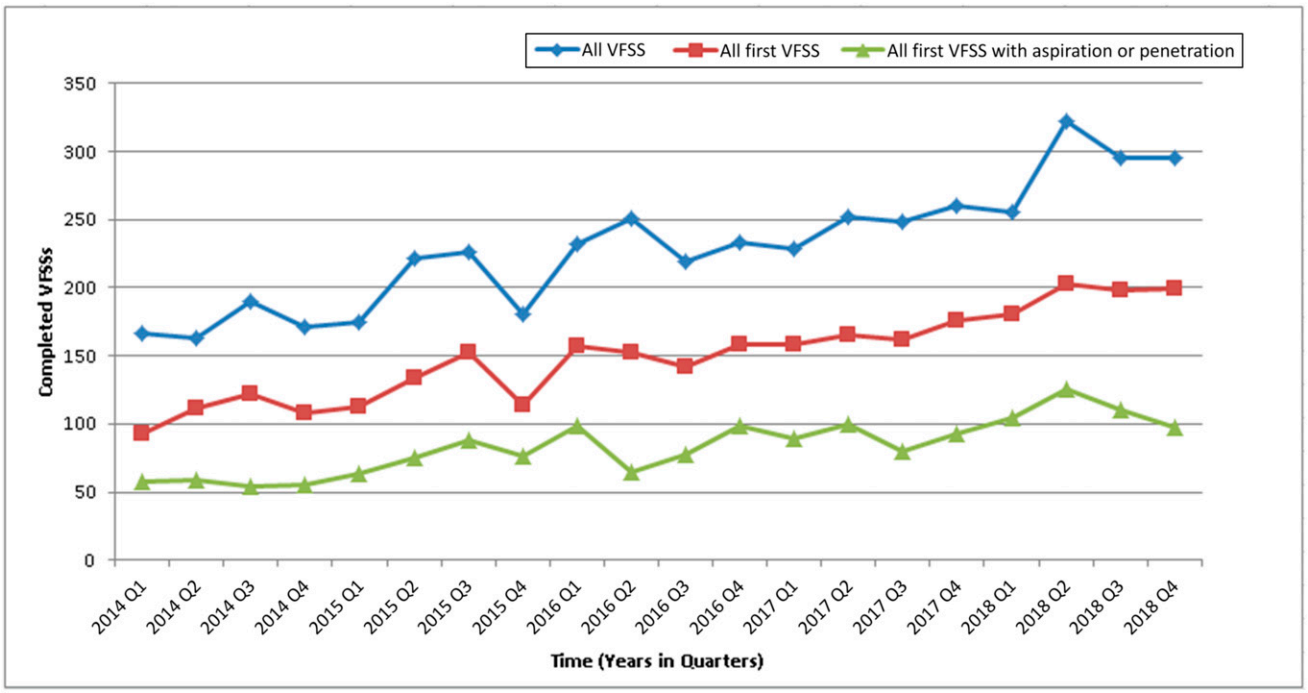

FIGURE 4

Frequency of total, first, and abnormal VFSSs performed over time. Q, quarter.

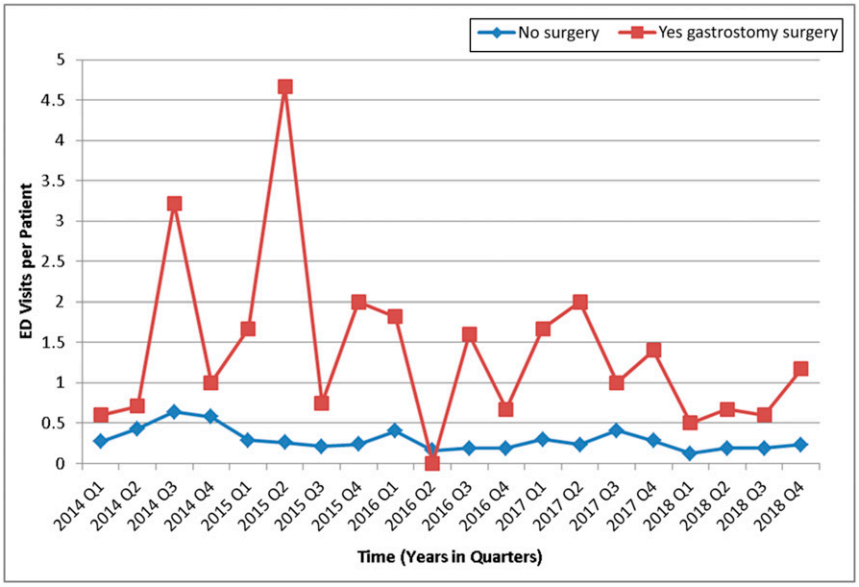

FIGURE 5
Rates of ED visits per patient within 6 months of initial abnormal VFSS in patients treated with gastrostomy tube placement versus those who were not. Q, quarter.

especially given that 1 of the barriers for providers to continue oral feeding is fear of increased pulmonary exacerbations. To address provider worry, additional supports were implemented for providers. For example, when a patient presented to radiology for a VFSS and aspiration of all textures was diagnosed, members of the aerodigestive team were paged, came to radiology to discuss the diagnosis, and arranged for a direct admission to the inpatient gastroenterology service in which attending physicians had all been educated on the importance of trying to initially maintain nasogastric and oral feeding rather than gastrostomy tube placement. Patients were then seen within 1 week of discharge by the aerodigestive team to provide supports for this approach.

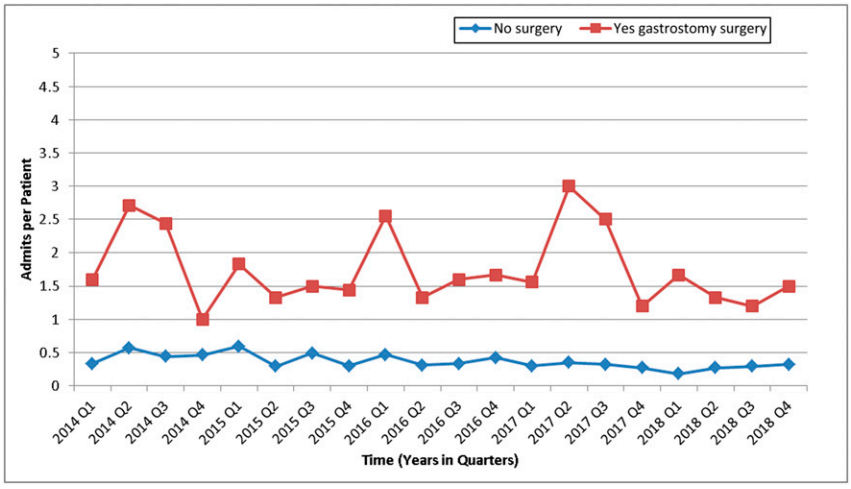

FIGURE 6
Rates of total hospital admissions per patient within 6 months of initial abnormal VFSS in patients treated with gastrostomy tube placement versus those who were not. Q, quarter.

Supporting the gastroenterology consultation service, a team of nurse practitioners, specializing in enteral tube consults, was also created to encourage oral feeding and, when possible, encourage nasogastric tube placement with close outpatient gastroenterology follow-up within 1 to 2 weeks of hospital discharge.

Often, there is a perception that if a gastrostomy tube is placed, the patient will be able to stay out of the hospital and have improved pulmonary outcomes. We have shown in this study and previous ones, that patients who have undergone gastrostomy tube placement may present to the ED more often for gastrostomy-related complications.[12] These data again are consistent with other published data noting the frequent complications and ED visits, especially infection or dislodgement, within the first month of gastrostomy tube placement, and highlight gastrostomy tube morbidity.[20,28] We have also found that patients with oropharyngeal dysphagia who were treated with gastrostomy tube placement compared with orally fed patients had twice the frequency of hospital readmissions within a year suggesting that some form of oral or nasogastric tube feedings may be a safer option.[12]

This EBG was developed to help attempt to standardize the management of infants and young children presenting with aspiration. To assure success, it was critical to have the key stakeholders within our division educate our colleagues on the importance of trying to maintain oral feeding and, when needed, have clinical support available from our aerodigestive center and other pediatric specialty teams who committed to caring for these complex patients and to assume the care if others felt uncomfortable with oral feeding.

Given the potential for pediatric swallow function to improve over

time, we felt the performance of a repeat VFSS and further assessment may be needed before additional permanent gastrostomy tube placement.[7] During the course of this guideline initiative, the baseline rates of obtaining any initial VFSS in this patient population increased over time, likely secondary to improved standardization from the guideline. In addition, patients with aspiration on their initial VFSS were more likely to have a repeat VFSS within a year. We feel this increase may be due to clinicians heightened awareness of aspiration as a component to patients' feeding difficulties, their desire to keep infants and children safely orally feeding, and only proceeding with gastrostomy tube placement when absolutely necessary. Through the implementation of this EBG and standardizing clinicians' approach to patients with aspiration before tube placement, we may be able to better disseminate some of the practices currently adopted at our hospital and potentially promote a more cost-effective approach to patients with oropharyngeal dysphagia.

This quality improvement initiative was built as an intervention of standardizing practice at a single tertiary pediatric medical center with an aerodigestive center. We feel that this quality initiative may be generalizable to similar hospitals with multidisciplinary teams available for consultation. There are some limitations to our study. First, because this was an electronic database quality initiative to reduce gastrostomy tubes, there is a lack of complete granularity of patient comorbidities, feeding interventions trialed, and barriers to sustained oral feeding; also, we were limited to only a year of baseline data because of limitations in our electronic medical records. Also, given the difficulty with coding patients who were treated with nasogastric tubes, data on their frequency of use were not available. Finally, we chose to look at the primary outcome of gastrostomy tube placement within 6 months of the initial abnormal VFSS because we felt that the majority of clinical decisions would be made within that time frame. However, there may have been a small number of patients who went on to have gastrostomy tube placement after 6 months, but decision-making this late was felt to be likely multifactorial in etiology, not just related to aspiration.

CONCLUSIONS

A standardized evaluation and approach for an infant or young child presenting with oropharyngeal dysphagia was successfully implemented and adopted by multiple providers at a larger tertiary pediatric institution. In doing so, we were able to successfully decrease the subsequent need for gastrostomy tube placement and associated costs without increasing subsequent hospital admissions or ED visits.

ACKNOWLEDGMENTS

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ABBREVIATIONS

BCH: Boston Children's Hospital
EBG: evidence-based guideline
ED: emergency department
VFSS: videofluoroscopic swallow study

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REFERENCES

1. Lundine JP, Dempster R, Carpenito K, et al. Incidence of aspiration in infants with single-ventricle physiology following hybrid procedure. *Congenit Heart Dis*. 2018;13(5):706–712
2. Duncan DR, Mitchell PD, Larson K, Rosen RL. Presenting signs and symptoms do not predict aspiration risk in children. *J Pediatr*. 2018;201:141–146
3. Sanchez K, Spittle AJ, Slattery JM, Morgan AT. Oromotor feeding in children born before 30 weeks' gestation and term-born peers at 12 months' corrected age. *J Pediatr*. 2016;178:113–118.e1
4. Benfer KA, Weir KA, Bell KL, Ware RS, Davies PSW, Boyd RN. Oropharyngeal dysphagia and cerebral palsy. *Pediatrics*. 2017;140(6):e20170731
5. Svystun O, Johannsen W, Persad R, Turner JM, Majaesic C, El-Hakim H. Dysphagia in healthy children: characteristics and management of a consecutive cohort at a tertiary centre. *Int J Pediatr Otorhinolaryngol*. 2017;99:54–59
6. Weir KA, McMahon S, Taylor S, Chang AB. Oropharyngeal aspiration and silent aspiration in children. *Chest*. 2011;140(3):589–597
7. Davis NL, Liu A, Rhein L. Feeding immaturity in preterm neonates: risk factors for oropharyngeal aspiration and timing of maturation. *J Pediatr Gastroenterol Nutr*. 2013;57(6):735–740
8. Karsch E, Irving SY, Aylward BS, Mahle WT. The prevalence and effects of

aspiration among neonates at the time of discharge. *Cardiol Young*. 2017;27(7): 1241–1247

9. Tutor JD, Gosa MM. Dysphagia and aspiration in children. *Pediatr Pulmonol*. 2012;47(4):321–337

10. Duncan DR, Larson K, Davidson K, May K, Rahbar R, Rosen RL. Feeding interventions are associated with improved outcomes in children with laryngeal penetration. *J Pediatr Gastroenterol Nutr*. 2019;68(2):218–224

11. Jadcherla SR, Khot T, Moore R, Malkar M, Gulati IK, Slaughter JL. Feeding methods at discharge predict long-term feeding and neurodevelopmental outcomes in preterm infants referred for gastrostomy evaluation. *J Pediatr*. 2017;181:125–130.e1

12. McSweeney ME, Kerr J, Amirault J, Mitchell PD, Larson K, Rosen R. Oral feeding reduces hospitalizations compared with gastrostomy feeding in infants and children who aspirate. *J Pediatr*. 2016;170:79–84

13. Lambert LM, Pike NA, Medoff-Cooper B, et al; Pediatric Heart Network Investigators. Variation in feeding practices following the Norwood procedure. *J Pediatr*. 2014;164: 237–242.e1

14. Indramohan G, Pedigo TP, Rostoker N, Cambare M, Grogan T, Federman MD. Identification of risk factors for poor feeding in infants with congenital heart disease and a novel approach to improve oral feeding. *J Pediatr Nurs*. 2017;35:149–154

15. Mussatto KA, Hoffmann R, Hoffman G, et al. Risk factors for abnormal developmental trajectories in young children with congenital heart disease. *Circulation*. 2015;132(8):755–761

16. Fox D, Campagna EJ, Friedlander J, Partrick DA, Rees DI, Kempe A. National trends and outcomes of pediatric gastrostomy tube placement. *J Pediatr Gastroenterol Nutr*. 2014;59(5):582–588

17. Sømme S, Bronsert M, Morrato E, Ziegler M. Frequency and variety of inpatient pediatric surgical procedures in the United States. *Pediatrics*. 2013; 132(6). Available at: www.pediatrics.org/cgi/content/full/132/6/e1466

18. Daveluy W, Guimber D, Mention K, et al. Home enteral nutrition in children: an 11-year experience with 416 patients. *Clin Nutr*. 2005;24(1):48–54

19. McSweeney ME, Smithers CJ. Advances in pediatric gastrostomy placement. *Gastrointest Endosc Clin N Am*. 2016; 26(1):169–185

20. Goldin AB, Heiss KF, Hall M, et al. Emergency department visits and readmissions among children after gastrostomy tube placement. *J Pediatr*. 2016;174:139–145.e2

21. Heyman MB, Harmatz P, Acree M, et al. Economic and psychologic costs for maternal caregivers of gastrostomy-dependent children. *J Pediatr*. 2004; 145(4):511–516

22. Jadcherla SR, Wang M, Vijayapal AS, Leuthner SR. Impact of prematurity and co-morbidities on feeding milestones in neonates: a retrospective study. *J Perinatol*. 2010;30(3):201–208

23. Simon TD, Cawthon ML, Popalisky J, Mangione-Smith R; Center of Excellence on Quality of Care Measures for Children with Complex Needs (COE4CCN). Development and validation of the Pediatric Medical Complexity Algorithm (PMCA) version 2.0. *Hosp Pediatr*. 2017;7(7):373–377

24. Simon TD, Cawthon ML, Stanford S, et al; Center of Excellence on Quality of Care Measures for Children with Complex Needs (COE4CCN) Medical Complexity Working Group. Pediatric Medical Complexity Algorithm: a new method to stratify children by medical complexity. *Pediatrics*. 2014;133(6). Available at: www.pediatrics.org/cgi/content/full/133/6/e1647

25. Wolter NE, Hernandez K, Irace AL, et al. A systematic process for weaning children with aspiration from thickened fluids. *JAMA Otolaryngol Head Neck Surg*. 2018;144(1):51–56

26. Benneyan JC, Lloyd RC, Plsek PE. Statistical process control as a tool for research and healthcare improvement. *Qual Saf Health Care*. 2003;12(6): 458–464

27. Provost LP, Murray MS. *The Health Care Data Guide: Learning From Data for Improvement*. San Francisco, CA: Jossey-Bass; 2011

28. McSweeney ME, Kerr J, Jiang H, Lightdale JR. Risk factors for complications in infants and children with percutaneous endoscopic gastrostomy tubes. *J Pediatr*. 2015;166: 1514–1519.e1